PATCH PANEL

COLOR LEGEND

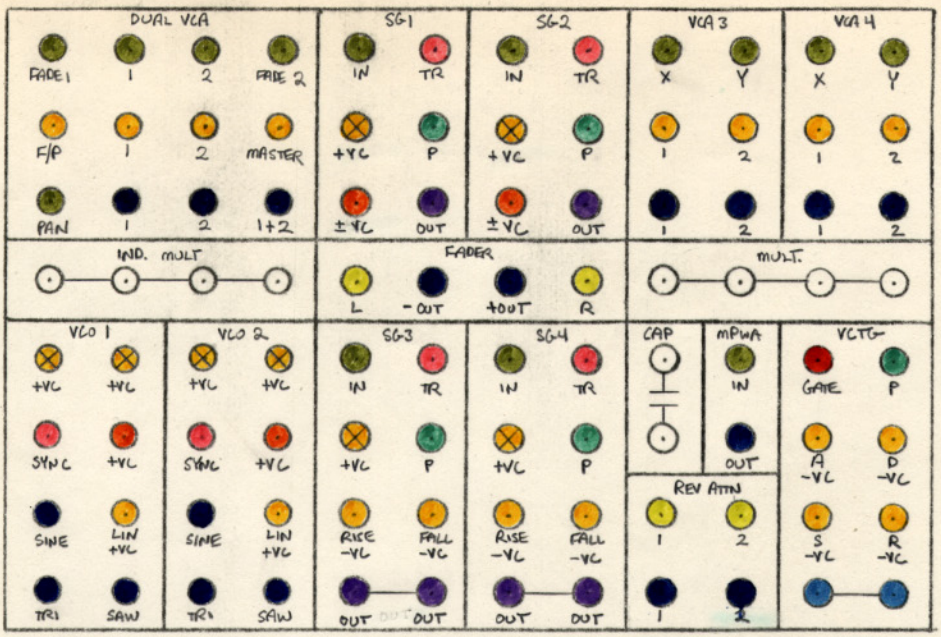
- UNASSIGNED

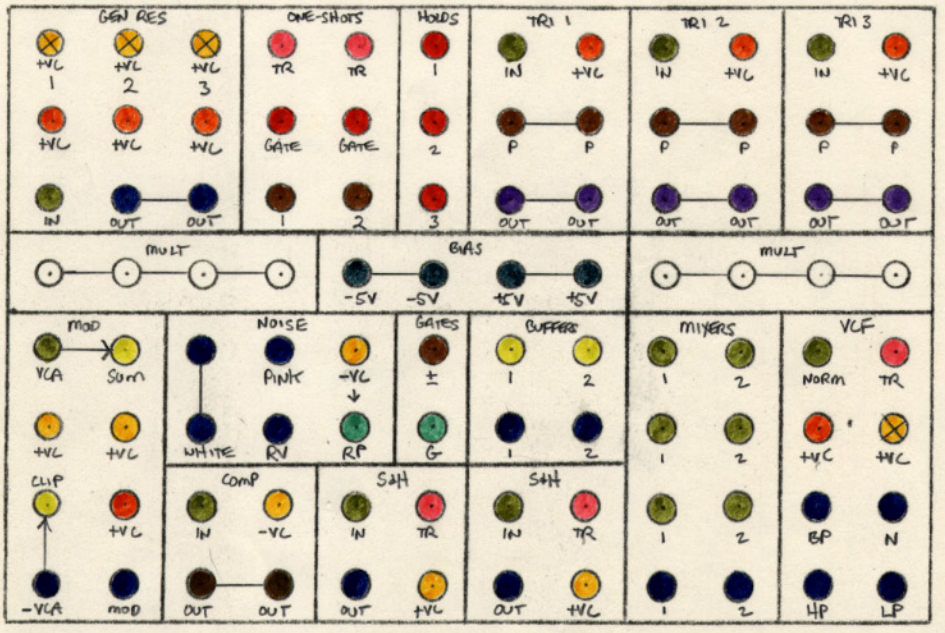
INPUTS

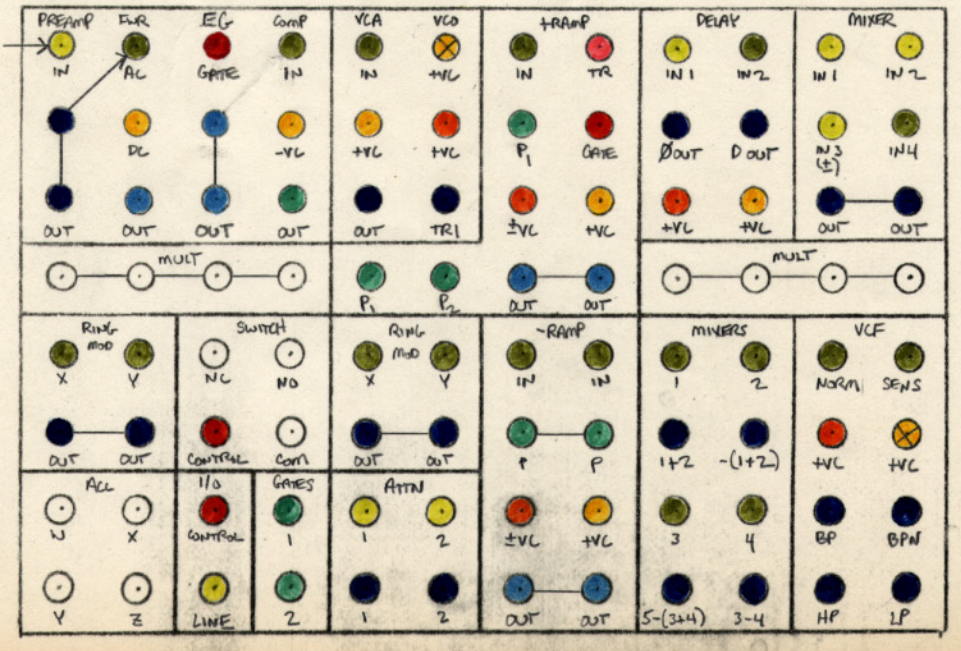
- MAIN
- MAIN WITH ATTENUATOR
- CONTROL
- CONTROL, 1VOLT/OCTAVE
- CONTROL WITH ATTENUATOR
- GATE
- TRIGGER

OUTPUTS

- BIPOLAR ANALOG
- BIPOLAR ANALOG, UNIPOLAR CYCLE
- UNIPOLAR ANALOG
- BIPOLAR BINARY
- UNIPOLAR BINARY
- FIXED BIAS

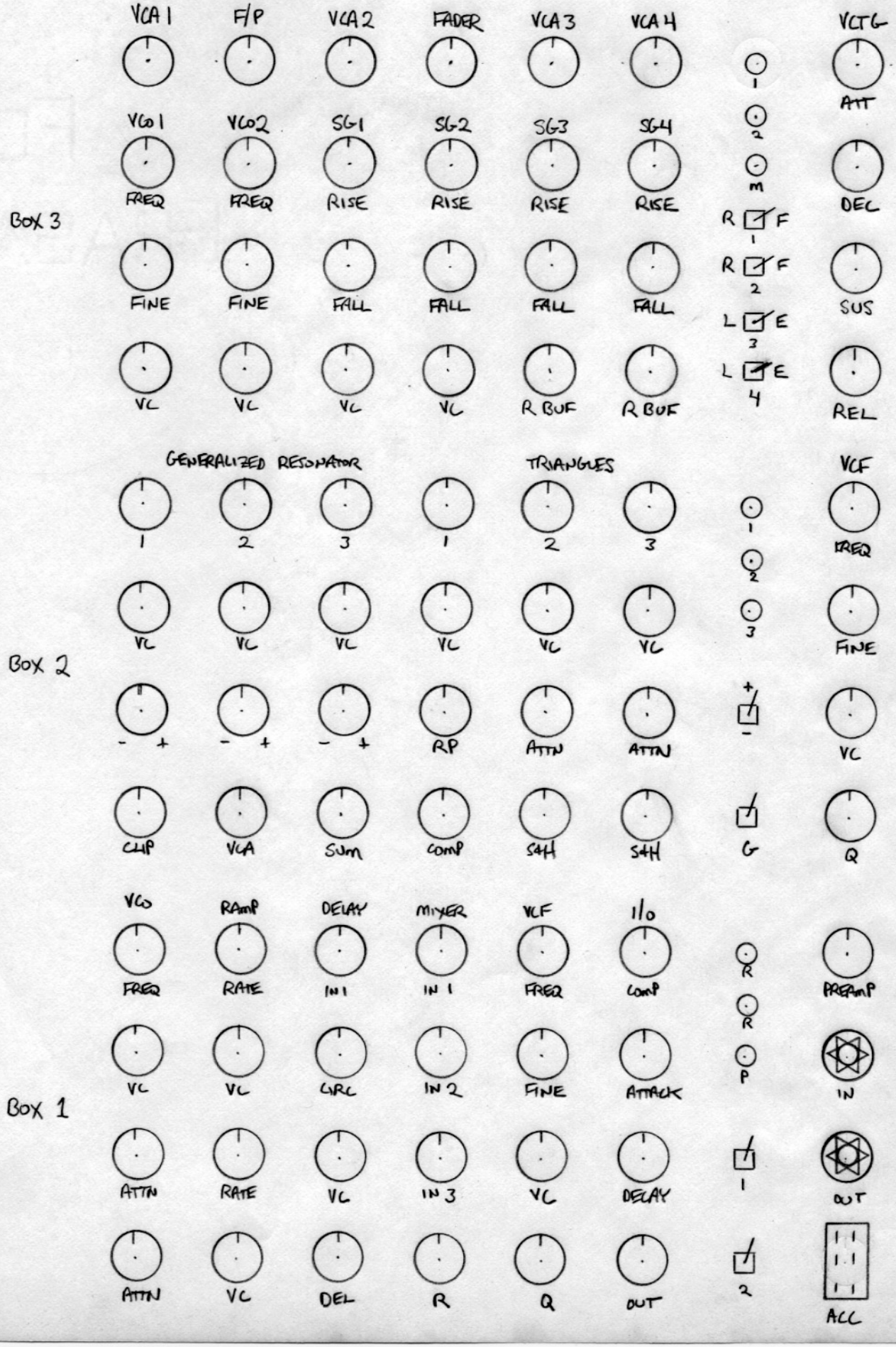




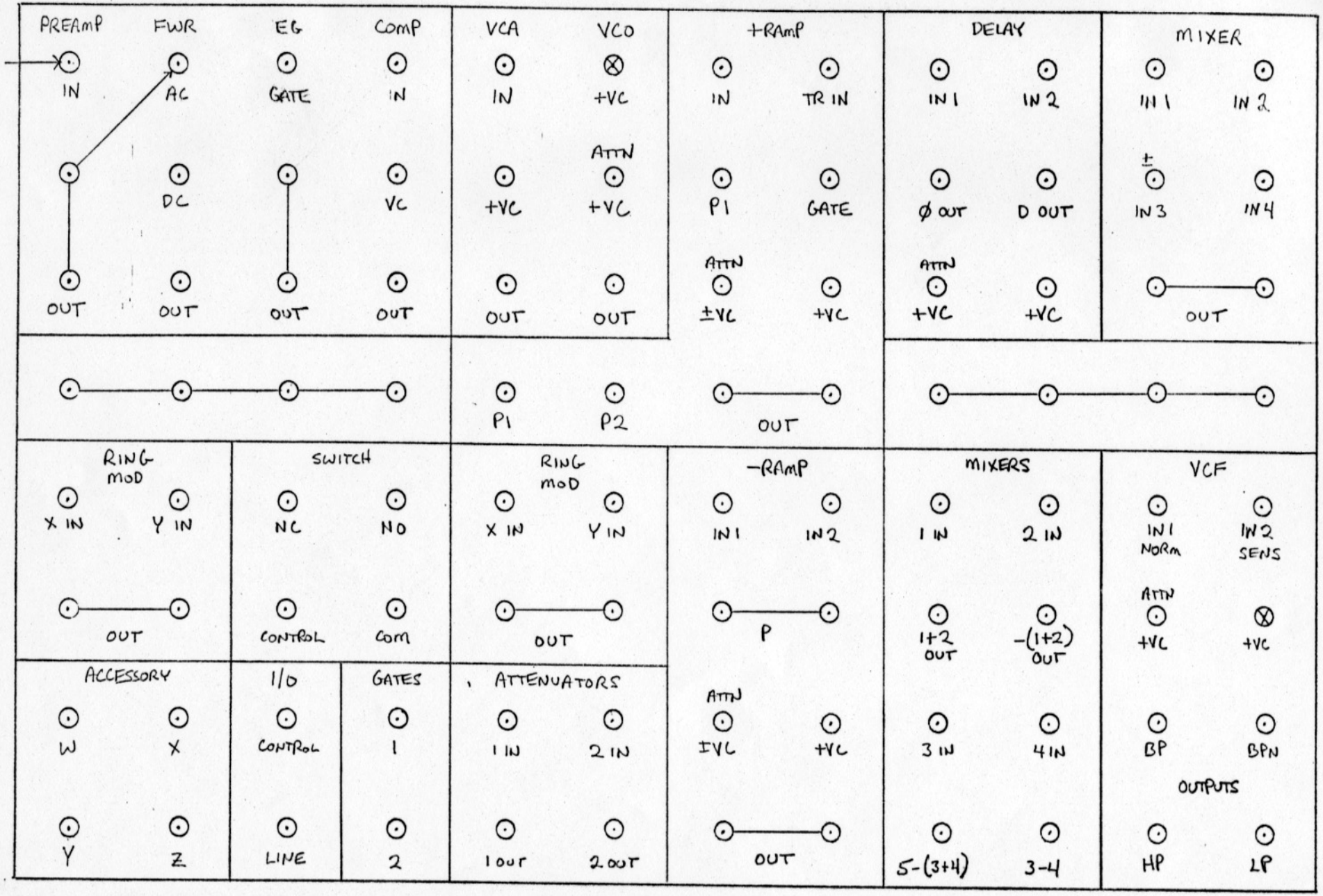


RICH BREWSTER, 5/80

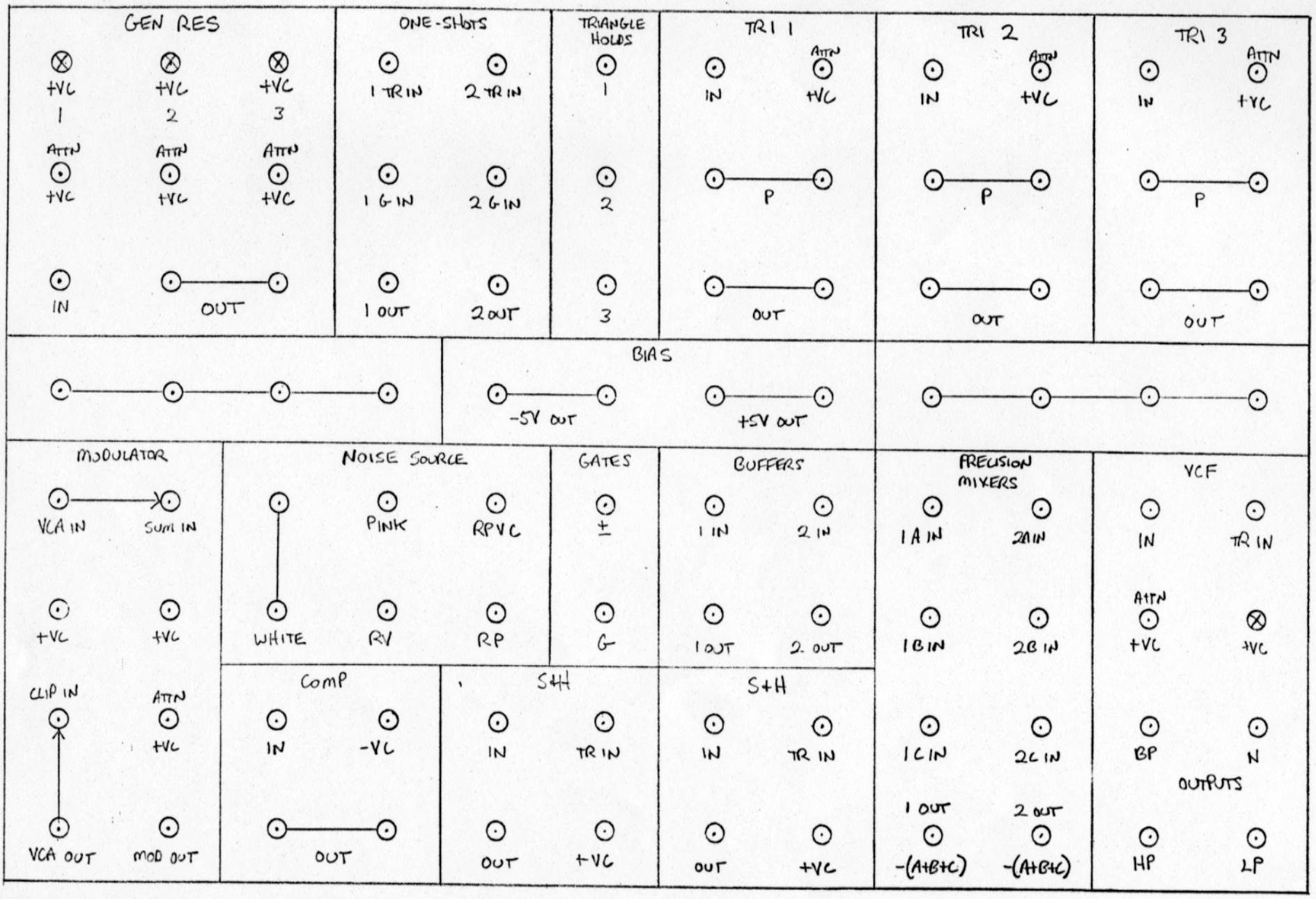
CONTROL PANELS



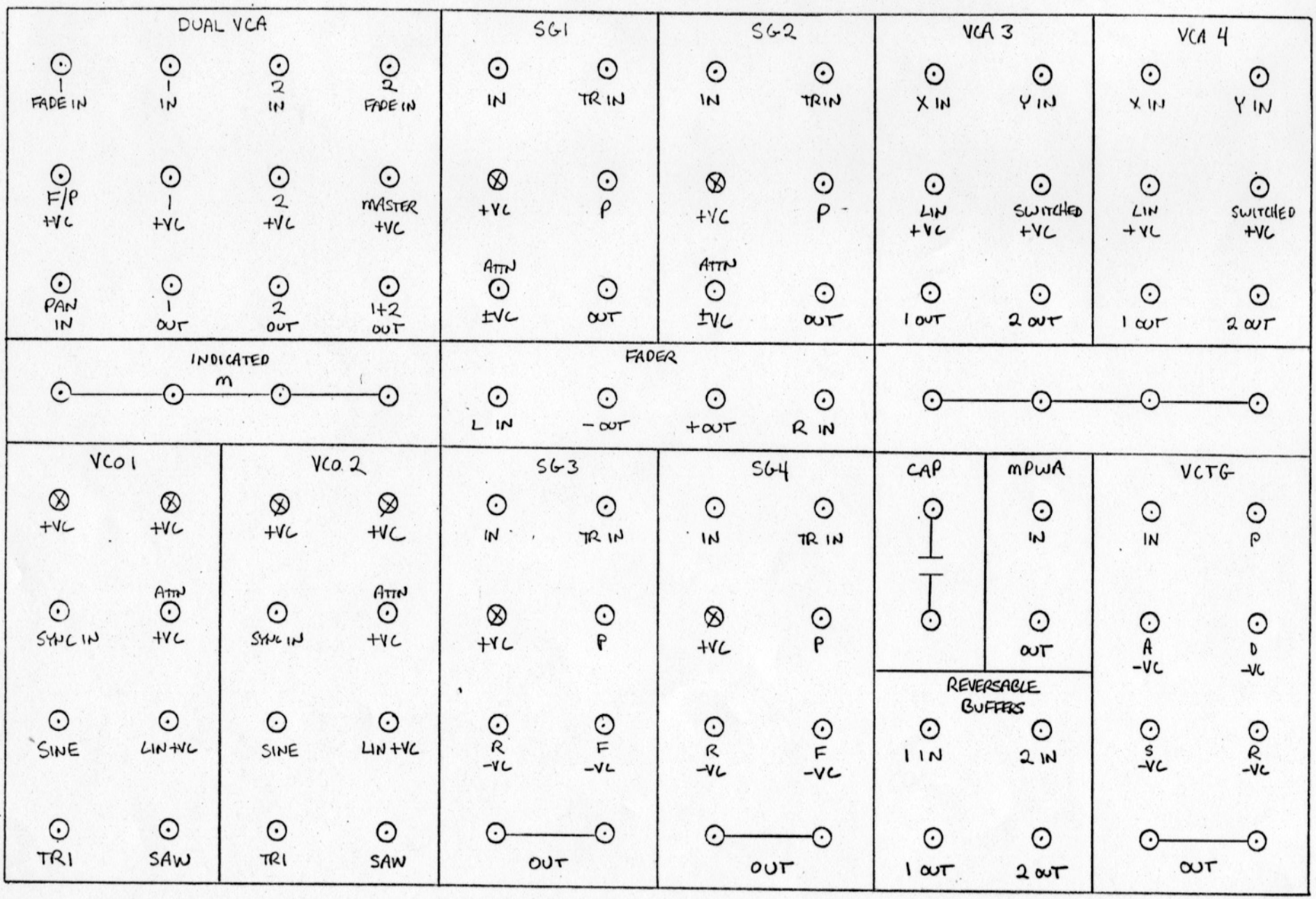
UNIT ONE PATCH PANEL



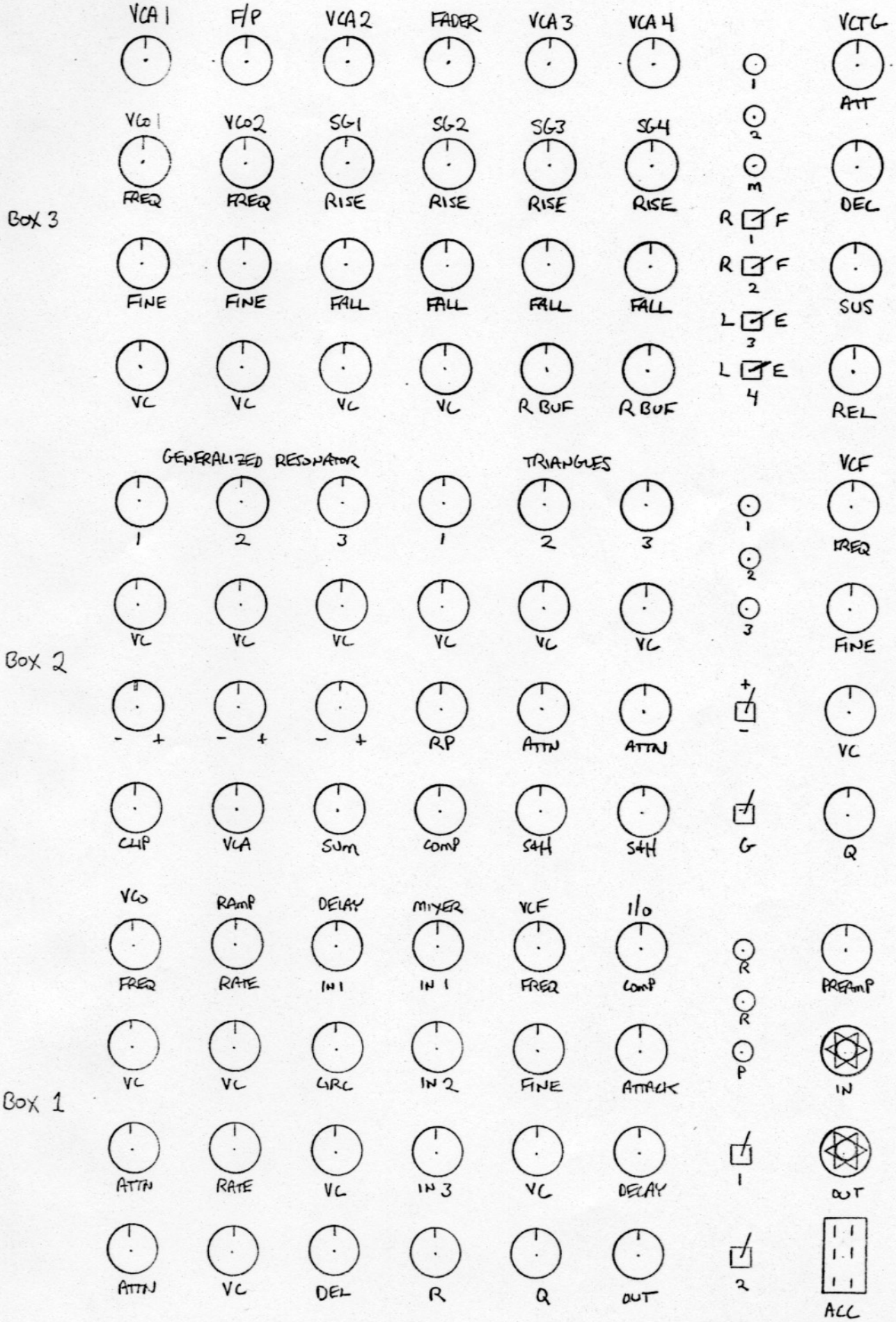
UNIT TWO PATCH PANEL



UNIT THREE PATCH PANEL



CONTROL PANELS



BOX 1
MODULE LIST

VCO - WIDE RANGE TRIANGLE, 1V/OCT TEMPCO STABILITY
VCA - AC COUPLED, NO PANEL CONTROLS
VCF - 4TH ORDER STATE VARIABLE, 1V/OCT TEMPCO STABILITY
ENVELOPE GENERATOR - SIMPLE AR, GATE DRIVEN
FULL WAVE RECTIFIER - ABSOLUTE VALUE CIRCUIT
I/O SWITCH WITH PREAMP AND LINE DRIVER
COMPARATOR
POSITIVE RAMP GENERATOR
NEGATIVE RAMP GENERATOR
ANALOG DELAY
MIXER WITH ATTENUATED INPUTS
UNATTENUATED INPUT MIXERS/INVERTERS
DUAL RING MODULATORS
BILATERAL ELECTRONIC SWITCH
DUAL MANUAL GATE SWITCHES
DUAL UNBUFFERED LINEAR ATTENUATORS
DUAL FOUR-POINT MULTIPLES
ACCESSORY CONNECTOR (KEYBOARD PATCH)

Box 2
MODULE LIST

THREE TRIANGLE MODULES
DUAL ONE-SHOTS (CONVERT TRIANGLE TO SLIT)
DUAL SLEW-LIMITED SAMPLE AND HOLDS
COMPARATOR
NOISE SOURCE
DUAL PRECISION INVERTING MIXERS
VCF - 2ND ORDER STATE VARIABLE, 1V/OCT TEMPCO STABILITY
TIMBRE MODULATOR / VCA
GENERALIZED RESONATOR
I GATE SWITCH
MANUAL GATE OR PULSE SWITCH
DUAL BUFFERED AUDIO TAPER ATTENUATORS, GAIN = +2
±5V BIAS SOURCES
DUAL FOUR-POINT MULTIPLES

Box 3
MODULE LIST

FOUR SLEW GENERATORS
DUAL WIDE RANGE VCO'S, 1V/OCT TEMPCO STABLE
DUAL VCA
DUAL VCA
MANUAL FADER
VOLTAGE CONTROLLED ENVELOPE GENERATOR
DUAL REVERSIBLE BUFFERS, GAIN = ±1.75
MULTI-PHASE WAVEFORM ANIMATOR
PATCHABLE CAPACITOR
DUAL 4-POINT MULTIPLES, ONE WITH INDICATOR

BRIEF MODULE DESCRIPTION

VOLTAGE CONTROLLED OSCILLATORS (SEE MULTIFUNCTION) — Box # 3

VCO 1, VCO 2

WIDE RANGE - SLOW LFO TO 20KHZ.
2 1V/OCT FM INPUTS, 1 ATTENUATED LOG FM INPUT.
LINEAR FM INPUT, SYNC INPUT.
SINE, TRIANGLE, SAWTOOTH WAVEFORMS.

VCO 3 — Box # 1

WIDE RANGE - SLOW LFO TO 20 KHZ.
1 1V/OCT FM INPUT, 1 ATTENUATED LOG FM INPUT.
TRIANGLE WAVEFORM.

VOLTAGE CONTROLLED AMPLIFIERS

VCA's 1 AND 2 (DUAL VCA) — Box # 3

USES: TWO INDEPENDENT LINEAR VCA'S.
VOLTAGE CONTROLLED FADE OR PAN WITH SEPERATE VC OF FADE/PAN AND FINAL LEVELS.
VOLTAGE CONTROLLED MIXING.

VCA 3, VCA 4 — Box # 3

EACH IS A UNIVERSAL AMPLITUDE PROCESSOR
USES: NORMAL VCA, REVERSE VCA.
FADE, REVERSE FADE.
PAN, REVERSE PAN.
SIMULTANEOUS FADE, PAN.
LINEAR OR EXPONENTIAL RESPONSE.

VCA 5 — Box # 1

SIMPLE LINEAR VCA, AC COUPLED INPUT.

VCA 6 (PART OF TIMBRE MODULATOR) — Box # 2

SIMPLE LINEAR VCA.
3 CONTROL INPUTS, SIGNAL IS INVERTED.

KEYBOARD — N.A.

3 OCTAVE DIGITAL KEYBOARD WITH:
MODULATION WHEEL FOR BEND OR MODULATION.
BUILT IN SINEWAVE VIBRATO OSCILLATOR.
KEYBOARD SPLIT FOR 5 OCTAVE COVERAGE.
TUNING OVER 1 OCTAVE RANGE.
1V/OCT OR ANY MICRO OR MACRO SCALING, + OR -.
PORTAMENTO, EXPONENTIAL.
AUTOMATIC ARPEGGIATION, RANDOM NOTE SELECTION.

Box #

VOLTAGE CONTROLLED FILTERS

VCF 1, FOURTH-ORDER STATE VARIABLE. 1

TWO SIGNAL INPUTS, NORMAL AND SENSITIVE.
TWO CONTROL INPUTS, 1V/OCT AND ATTENUATED LOG.
LOW, HIGH, & BAND PASS, PLUS BAND PASS NOTCH OUTPUTS.

VCF 2, SECOND-ORDER STATE VARIABLE. 2

TWO SIGNAL INPUTS, NORMAL AND TRIGGER.
TWO CONTROL INPUTS, 1V/OCT AND ATTENUATED LOG.
LOW, HIGH, & BAND PASS, PLUS NOTCH OUTPUTS.
BOTH VCF 1 AND 2 CAN BE MADE TO FUNCTION AS SINE WAVE OSCILLATORS WITH SUBAUDIO TO 20 kHz RANGE.

ENVELOPE GENERATORS (SEE MULTIFUNCTION) 3

VCTG 1

WIDE RANGE ADSR TYPE GENERATOR.
ALL PARAMETERS VOLTAGE CONTROLLABLE.
CAN BE PATCHED TO SELF-CYCLE.

EG 1 - SIMPLE GATE DRIVEN ASR. 1

RING MODULATORS

MULTIPLIER 1, MULTIPLIER 2. 1

X & Y INPUTS, OUTPUT.
MULTIPLIER 1 HAS AC COUPLED INPUTS.

NOISE SOURCE 2

WHITE, PINK, LOW FREQUENCY, & RANDOM PULSE OUTPUTS.
RANDOM PULSE RATE IS VOLTAGE CONTROLLABLE.

ANALOG DELAY 1

VOLTAGE CONTROLLED DELAY.
TWO SIGNAL INPUTS, 1 ATTENUATED.
TWO CONTROL INPUTS, 1 ATTENUATED.
PHASOR OUTPUT, DELAYED OUTPUT.
RECIRCULATION / FLANGER CONTROL.

SAMPLE AND HOLD (1 & 2) 2

SLEW LIMITED S&H WITH VC OF SLEW RATE.
SIGNAL IN, SAMPLE TRIGGER IN, OUTPUT.

MULTIFUNCTION MODULES

Box #

SLEW GENERATORS 1, 2, 3, 4. — 3

USES: WIDE RANGE VCO, SLOW LFO TO 5 KHZ.
AD, AR, ASR GENERATOR.
TWO TOGETHER CAN MAKE VC ADSR.
LINEAR VC LAG-PROCESSOR.
SEPERATE VC OF ATTACK AND DECAY.
ENVELOPE FOLLOWER.
VC FREQUENCY DIVIDER.

POSITIVE AND NEGATIVE RAMP GENERATORS. — 1

USES: WIDE RANGE VCO, SLOW LFO TO 2 KHZ.
COMBINED TO FORM AD, AR, ASR GENERATOR.
LINEAR VC LAG PROCESSOR.
ENVELOPE FOLLOWER (NEG).
VC FREQUENCY DIVIDER.

TRIANGLES 1, 2, 3. — 2

USES: WIDE RANGE VCO, SLOW LFO TO 1 KHZ.
LINEAR VC LAG PROCESSOR.
ASR ENVELOPE GENERATOR.
SLEW LIMITED SAMPLE AND HOLD (WITH ONE SHOT).
TRACK AND HOLD.

MULTIPLE CONNECTIONS

TWO 4-POINT COMMON PATCHPOINTS ARE AVAILABLE ONEACH BOX. — 1, 2, 3
BOX 3 HAS A MULTIPLE MONITERED BY LED.

CAPACITOR

A PATCHABLE 2.2mf NONPOLAR CAPACITOR IS PROVIDED FOR AC COUPLING PATCHES. — 3

BIAS

FIXED + AND − FIVE VOLT BIAS OUTPUTS ARE MADE AVAILABLE ON THE PATCHBAY. — 2

MIXERS

Box #

MIXER 1: 1

TWO NON-INVERTING ATTENUATED INPUTS, MAX GAIN OF +2.33.
CENTER OFF INVERTING OR NON INVERTING UNITY GAIN ATTENUATED INPUT.
UNITY GAIN NON-ATTENUATED INPUT.

MIXER 2: 1

TWO NON-ATTENUATED INPUTS.
SUM AND INVERTED SUM OUTPUTS.

MIXER 3: 1

TWO NON-ATTENUATED INPUTS.
SUM AND DIFFERENCE OUTPUTS.

MIXERS 4, 5: 2

PRECISION 3 INPUT NON-ATTENUATED INVERTING MIXERS.

MANUAL ATTENUATORS

ATTENUATOR 1 & 2: 1

TWO PATCHABLE POTENTIOMETERS, 100K LINEAR.

BUFFERS 1 & 2: 2

TWO BUFFER AUDIO TAPER ATTENUATORS, MAX GAIN = +2.

REVERSIBLE BUFFERS: 3

TWO CENTER OFF INVERTING OR NON-INVERTING
VARIABLE GAIN BUFFERS, MAX GAIN = ±1.75.

MANUAL FADER: 3

LEFT AND RIGHT INPUTS.
INVERTING AND NON INVERTING UNITY GAIN OUTPUTS.
FULLY BUFFERED.

MANUAL GATE SWITCHES

1 AND 2: 1

DEBOUNCED GATE, ON OR MOMENTARY ACTION.

GATE: 2

GIVES EITHER DEBOUNCED GATE OR
1 MS PULSE.

± GATE: 2

NOT DEBOUNCED ACCESS TO ±5V BIAS.

SPECIAL MODULES

Box #

MULTIPHASED WAVEFORM ANIMATOR: 3

ONE INPUT, ONE OUTPUT DEVICE FOR IMPARTING 8 SIMULTANEOUS PHASE SHIFTS TO A SAWTOOTH WAVE, OR ENHANCEMENT OF OTHER SIGNALS.

TIMBRE MODULATOR: 2

CLIPPING CIRCUIT AND VCA FOR VC OF HARMONIC CONTENT.
CLIPPER AND VCA USEABLE SEPERATELY.

GENERALIZED RESONATOR: 2

THREE CASCADED VOLTAGE CONTROLLED MONOSTABLES.
SIGNAL INPUT AND OUTPUT.
SIX VC INPUTS, 3 ATTENUATED.
MANUAL OUTPUT MIXER.
THIS IS AN EXPERIMENTAL "PULSE MODULATOR".

INPUT/OUTPUT CONTROL 1

PROVIDES BUFFERING AND LEVEL MATCHING WITH IN/OUT VC SWITCHING. PROVIDED FOR USE WHEN PROCESSING GUITAR, MIC, ETC.

ONE SHOTS 2

USE WITH TRIANGLE TO MAKE SAMPLE AND HOLD.
SAMPLE, TRACK INPUTS, OUTPUT.
USE TO GENERATE PULSE WAVEFORMS.

MISCELLANEOUS MODULES

Box #

COMPARATORS

COMP 1: 1

COMPARES INPUT WITH REFERENCE VOLTAGE, OUTPUT IS HIGH IF INPUT IS HIGHER THAN REFERENCE.
REFERENCE IS MANUALLY AND VOLTAGE CONTROLLABLE.
USE FOR PULSE GENERATION AND MODULATION,
SQUARE WAVE GENERATION,
GATE SIGNAL GENERATION.

COMP 2: 2

SAME AS COMP 1 EXCEPT FOR BIPOLAR OUTPUT.

FULL WAVE RECTIFIER

FWR 1: 1

ABSOLUTE VALUE CRCUIT, INVERTS INPUT IF NEGATIVE.
BOTH AC AND DC COUPLED INPUTS.
USE AS TIMBRE MODIFIER, "FUZZTONE",
VC WAVESHAPER.

CONTROLLED SWITCH 1

SINGLE POLE DOUBLE THROW SWITCH, ELECTRONICALLY CONTROLLED BY GATE INPUT.
COMMON TERMINAL MAY BE USE AS EITHER INPUT OR OUTPUT.

BRIEF MODULE DESCRIPTION

VOLTAGE CONTROLLED OSCILLATORS (SEE MULTIFUNCTION) — Box

VCO 1, VCO 2 — 3

WIDE RANGE - SLOW LFO TO 20 KHZ.
2 1V/OCT FM INPUTS, 1 ATTENUATED LOG FM INPUT.
LINEAR FM INPUT, SYNC INPUT.
SINE, TRIANGLE, SAWTOOTH WAVEFORMS.

VCO 3 — 1

WIDE RANGE - SLOW LFO TO 20 KHZ.
1 1V/OCT FM INPUT, 1 ATTENUATED LOG FM INPUT.
TRIANGLE WAVEFORM.

VOLTAGE CONTROLLED AMPLIFIERS

VCA's 1 AND 2 (DUAL VCA) — 3

USES: TWO INDEPENDENT LINEAR VCA'S.
VOLTAGE CONTROLLED FADE OR PAN WITH
SEPERATE VC OF FADE/PAN AND FINAL LEVELS.
VOLTAGE CONTROLLED MIXING.

VCA 3, VCA 4 — 3

EACH IS A UNIVERSAL AMPLITUDE PROCESSOR
USES: NORMAL VCA, REVERSE VCA.
FADE, REVERSE FADE.
PAN, REVERSE PAN.
SIMULTANEOUS FADE, PAN.
LINEAR OR EXPONENTIAL RESPONSE.

VCA 5 — 1

SIMPLE LINEAR VCA, AC COUPLED INPUT.

VCA 6 (PART OF TIMBRE MODULATOR) — 2

SIMPLE LINEAR VCA.
3 CONTROL INPUTS, SIGNAL IS INVERTED.

KEYBOARD — N.A.

3 OCTAVE DIGITAL KEYBOARD WITH:
MODULATION WHEEL FOR BEND OR MODULATION.
BUILT IN SINEWAVE VIBRATO OSCILLATOR.
KEYBOARD SPLIT FOR 5 OCTAVE COVERAGE.
TUNING OVER 1 OCTAVE RANGE.
1V/OCT OR ANY MICRO OR MACRO SCALING, + OR -.
PORTAMENTO, EXPONENTIAL.
AUTOMATIC ARPEGGIATION, RANDOM NOTE SELECTION.

VOLTAGE CONTROLLED FILTERS

Box #

VCF 1, FOURTH-ORDER STATE VARIABLE. — 1

TWO SIGNAL INPUTS, NORMAL AND SENSITIVE.
TWO CONTROL INPUTS, 1V/OCT AND ATTENUATED LOG.
LOW, HIGH, & BAND PASS, PLUS BAND PASS NOTCH OUTPUTS.

VCF 2, SECOND-ORDER STATE VARIABLE. — 2

TWO SIGNAL INPUTS, NORMAL AND TRIGGER.
TWO CONTROL INPUTS, 1V/OCT AND ATTENUATED LOG.
LOW, HIGH, + BAND PASS, PLUS NOTCH OUTPUTS.

BOTH VCF 1 AND 2 CAN BE MADE TO FUNCTION AS SINE WAVE OSCILLATORS WITH SUBAUDIO TO 20 KHZ RANGE.

ENVELOPE GENERATORS (SEE MULTIFUNCTION) — 3

VCTG 1

WIDE RANGE ADSR TYPE GENERATOR.
ALL PARAMETERS VOLTAGE CONTROLLABLE.
CAN BE PATCHED TO SELF-CYCLE.

EG 1 - SIMPLE GATE DRIVEN ASR. — 1

RING MODULATORS

MULTIPLIER 1, MULTIPLIER 2. — 1

X & Y INPUTS, OUTPUT.
MULTIPLIER 1 HAS AC COUPLED INPUTS.

NOISE SOURCE — 2

WHITE, PINK, LOW FREQUENCY, & RANDOM PULSE OUTPUTS.
RANDOM PULSE RATE IS VOLTAGE CONTROLLABLE.

ANALOG DELAY — 1

VOLTAGE CONTROLLED DELAY.
TWO SIGNAL INPUTS, 1 ATTENUATED.
TWO CONTROL INPUTS, 1 ATTENUATED.
PHASOR OUTPUT, DELAYED OUTPUT.
RECIRCULATION / FLANGER CONTROL.

SAMPLE AND HOLD (1 & 2) — 2

SLEW LIMITED S&H WITH VC OF SLEW RATE.
SIGNAL IN, SAMPLE TRIGGER IN, OUTPUT.

MISCELLANEOUS MODULES

Box #

COMPARATORS

Comp 1: 1

COMPARES INPUT WITH REFERENCE VOLTAGE, OUTPUT IS HIGH IF INPUT IS HIGHER THAN REFERENCE.
REFERENCE IS MANUALLY AND VOLTAGE CONTROLLABLE.
USE FOR PULSE GENERATION AND MODULATION,
SQUARE WAVE GENERATION,
GATE SIGNAL GENERATION.

Comp 2: 2

SAME AS COMP 1 EXCEPT FOR BIPOLAR OUTPUT.

FULL WAVE RECTIFIER

FWR 1: 1

ABSOLUTE VALUE CIRCUIT, INVERTS INPUT IF NEGATIVE.
BOTH AC AND DC COUPLED INPUTS.
USE AS TIMBRE MODIFIER, "FUZZTONE",
VC WAVESHAPER.

CONTROLLED SWITCH 1

SINGLE POLE DOUBLE THROW SWITCH, ELECTRONICALLY CONTROLLED BY GATE INPUT.
COMMON TERMINAL MAY BE USE AS EITHER INPUT OR OUTPUT.

MULTIFUNCTION MODULES

Box #

SLEW GENERATORS 1, 2, 3, 4. — 3

USES: WIDE RANGE VCO, SLOW LFO TO 5 KHZ.
AD, AR, ASR GENERATOR.
TWO TOGETHER CAN MAKE VC ADSR.
LINEAR VC LAG-PROCESSOR.
SEPERATE VC OF ATTACK AND DECAY.
ENVELOPE FOLLOWER.
VC FREQUENCY DIVIDER.

POSITIVE AND NEGATIVE RAMP GENERATORS. — 1

USES: WIDE RANGE VCO, SLOW LFO TO 2 KHZ.
COMBINED TO FORM AD, AR, ASR GENERATOR.
LINEAR VC LAG PROCESSOR.
ENVELOPE FOLLOWER (NEG).
VC FREQUENCY DIVIDER.

TRIANGLES 1, 2, 3. — 2

USES: WIDE RANGE VCO, SLOW LFO TO 1 KHZ.
LINEAR VC LAG PROCESSOR.
ASR ENVELOPE GENERATOR.
SLEW LIMITED SAMPLE AND HOLD (WITH ONE SHOT).
TRACK AND HOLD.

MULTIPLE CONNECTIONS

TWO 4-POINT COMMON PATCHPOINTS ARE AVAILABLE ONEACH BOX. — 1, 2, 3
BOX 3 HAS A MULTIPLE MONITERED BY LED.

CAPACITOR

3

A PATCHABLE 2.2mf NONPOLAR CAPACITOR IS PROVIDED FOR AC COUPLING PATCHES.

BIAS

2

FIXED + AND − FIVE VOLT BIAS OUTPUTS ARE MADE AVAILABLE ON THE PATCHBAY.

MIXERS

Box #

MIXER 1: 1

TWO NON-INVERTING ATTENUATED INPUTS, MAX GAIN OF +2.33.
CENTER OFF INVERTING OR NON INVERTING UNITY GAIN ATTENUATED INPUT.
UNITY GAIN NON-ATTENUATED INPUT.

MIXER 2: 1

TWO NON-ATTENUATED INPUTS.
SUM AND INVERTED SUM OUTPUTS.

MIXER 3: 1

TWO NON-ATTENUATED INPUTS.
SUM AND DIFFERENCE OUTPUTS.

MIXERS 4, 5: 2

PRECISION 3 INPUT NON-ATTENUATED INVERTING MIXERS.

MANUAL ATTENUATORS

ATTENUATOR 1 & 2: 1

TWO PATCHABLE POTENTIOMETERS, 100k LINEAR.

BUFFERS 1 & 2: 2

TWO BUFFER AUDIO TAPER ATTENUATORS, MAX GAIN = +2.

REVERSIBLE BUFFERS:

TWO CENTER OFF INVERTING OR NON-INVERTING 3
VARIABLE GAIN BUFFERS, MAX GAIN = ±1.75.

MANUAL FADER: 3

LEFT AND RIGHT INPUTS.
INVERTING AND NON INVERTING UNITY GAIN OUTPUTS.
FULLY BUFFERED.

MANUAL GATE SWITCHES

1 AND 2: 1

DEBOUNCED GATE, ON OR MOMENTARY ACTION.

GATE: 2

GIVES EITHER DEBOUNCED GATE OR
1ms PULSE.

± GATE: 2

NOT DEBOUNCED ACCESS TO ±5V BIAS.

SPECIAL MODULES

Box #

MULTIPHASED WAVEFORM ANIMATOR: 3

ONE INPUT, ONE OUTPUT DEVICE FOR IMPARTING 8 SIMULTANEOUS PHASE SHIFTS TO A SAWTOOTH WAVE, OR ENHANCEMENT OF OTHER SIGNALS.

TIMBRE MODULATOR: 2

CLIPPING CIRCUIT AND VCA FOR VC OF HARMONIC CONTENT.
CLIPPER AND VCA USEABLE SEPERATELY.

GENERALIZED RESONATOR: 2

THREE CASCADED VOLTAGE CONTROLLED MONOSTABLES.
SIGNAL INPUT AND OUTPUT.
SIX VC INPUTS, 3 ATTENUATED.
MANUAL OUTPUT MIXER.
THIS IS AN EXPERIMENTAL "PULSE MODULATOR".

INPUT/OUTPUT CONTROL 1

PROVIDES BUFFERING AND LEVEL MATCHING WITH IN/OUT VC SWITCHING. PROVIDED FOR USE WHEN PROCESSING GUITAR, MIC, ETC.

ONE SHOTS 2

USE WITH TRIANGLE TO MAKE SAMPLE AND HOLD.
SAMPLE, TRACK INPUTS, OUTPUT.
USE TO GENERATE PULSE WAVEFORMS.

MISCELLANEOUS MODULES

Box #

COMPARATORS

Comp 1: 1

COMPARES INPUT WITH REFERENCE VOLTAGE, OUTPUT IS HIGH IF INPUT IS HIGHER THAN REFERENCE.
REFERENCE IS MANUALLY AND VOLTAGE CONTROLLABLE.
USE FOR PULSE GENERATION AND MODULATION,
SQUARE WAVE GENERATION,
GATE SIGNAL GENERATION.

Comp 2: 2

SAME AS COMP 1 EXCEPT FOR BIPOLAR OUTPUT.

FULL WAVE RECTIFIER

FWR 1: 1

ABSOLUTE VALUE CRCUIT, INVERTS INPUT IF NEGATIVE.
BOTH AC AND DC COUPLED INPUTS.
USE AS TIMBRE MODIFIER, "FUZZTONE",
VC WAVESHAPER.

CONTROLLED SWITCH 1

SINGLE POLE DOUBLE THROW SWITCH, ELECTRONICALLY CONTROLLED BY GATE INPUT.
COMMON TERMINAL MAY BE USE AS EITHER INPUT OR OUTPUT.

BOX 1
MODULE LIST

VCO - WIDE RANGE TRIANGLE, 1V/OCT TEMPCO STABILITY
VCA - AC COUPLED, NO PANEL CONTROLS
VCF - 4TH ORDER STATE VARIABLE, 1V/OCT TEMPCO STABILITY
ENVELOPE GENERATOR - SIMPLE AR, GATE DRIVEN
FULL WAVE RECTIFIER - ABSOLUTE VALUE CIRCUIT
I/O SWITCH WITH PREAMP AND LINE DRIVER
COMPARATOR
POSITIVE RAMP GENERATOR
NEGATIVE RAMP GENERATOR
ANALOG DELAY
MIXER WITH ATTENUATED INPUTS
UNATTENUATED INPUT MIXERS / INVERTERS
DUAL RING MODULATORS
BILATERAL ELECTRONIC SWITCH
DUAL MANUAL GATE SWITCHES
DUAL UNBUFFERED LINEAR ATTENUATORS
DUAL FOUR-POINT MULTIPLES
ACCESSORY CONNECTOR (KEYBOARD PATCH)

BOX 2
MODULE LIST

THREE TRIANGLE MODULES
DUAL ONE-SHOTS (CONVERT TRIANGLE TO SLIT)
DUAL SLEW-LIMITED SAMPLE AND HOLDS
COMPARATOR
NOISE SOURCE
DUAL PRECISION INVERTING MIXERS
VCF - 2ND ORDER STATE VARIABLE, 1V/OCT TEMPCO STABILITY
TIMBRE MODULATOR / VCA
GENERALIZED RESONATOR
I GATE SWITCH
MANUAL GATE OR PULSE SWITCH
DUAL BUFFERED AUDIO TAPER ATTENUATORS, GAIN = +2
±5V BIAS SOURCES
DUAL FOUR-POINT MULTIPLES

BOX 3
MODULE LIST

FOUR SLEW GENERATORS
DUAL WIDE RANGE VCO'S, 1V/OCT TEMPCO STABLE
DUAL VCA
DUAL VCA
MANUAL FADER
VOLTAGE CONTROLLED ENVELOPE GENERATOR
DUAL REVERSIBLE BUFFERS, GAIN = ±1.75
MULTI-PHASE WAVEFORM ANIMATOR
PATCHABLE CAPACITOR
DUAL 4-POINT MULTIPLES, ONE WITH INDICATOR

AUDIO SYNTHESIZER
SYSTEM MANUAL + DOCUMENTATION
7/80, RICH BREWSTER

CONTENTS:

① ~~LISTING OF SYSTEM MODULES~~ + PACKAGING OVERVIEW
② DISCUSSION OF SIGNAL STANDARDS
③ FUNCTIONAL DISCRIPTION OF EACH MODULE
④ SCHEMATICS

(arrows indicate items ① and ② swapped; "LISTING OF SYSTEM MODULES" boxed)

THE SYSTEM DESCRIBED HERE IS PHYSICALLY CONTAINED IN 4 PACKAGES, EACH SEPERATELY POWERED AND USABLE INDIVIDUALLY OR TOGETHER. ~~AS A LARGER SYSTEM~~ THEY ARE REFERRED TO AS BOXES #1, #2, #3, AND KEYBOARD. BOXES #1 – #3 ARE RACK MOUNTABLE; EASILY FASTEN TOGETHER AND COME APART TO SUIT USAGE NEEDS.

EACH 5 1/4" x 19" + 2.

MODULES ARE ELECTRICALLY DISCRETE, BUT CONTROL PANELS AND PATCH BAYS ARE INTEGRATED AND NON MODULAR; FOR THE PURPOSE OF CONVENIENT AND ~~ELEGANCE~~ VERSATILE PATCHING, THE PATCHBAYS OCCUPY A LOCALIZED PANEL SPACE SO TO AVOID THE PATCHCORD-ACROSS-CONTROLPANEL MAZE. THIS METHOD REQUIRES A BIT MORE FAMILIZATON WITH THE PANEL LAYOUT THAN WITH TOTALLY MODULAR SYSTEMS AS CONTROLS AND PATCH JACKS ARE PHYSICALLY SEPERATED.

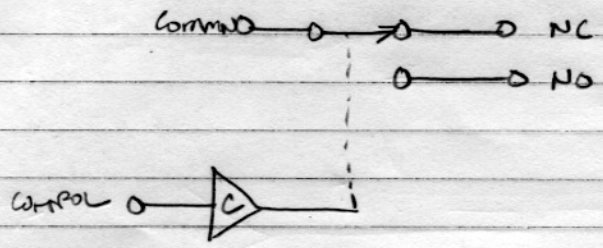
PATCHES ARE ACCOMPLISHED WITH POINT TO POINT PATCH CORDS, UTILIZING THE 96 JACKS ON EACH BAY OF BOXES 1, 2, + 3. MULTIPLE CONNECTIONS ARE MADE IN ANY OF 3 WAYS: MULTIPLE OUTPUTS FROM MODULES, 4-JACK PANEL MULTIPLES, 3-LEGGED PATCHCORDS (IDENTIFIED BY WHITE BAND). PATCHCORDS ARE COLOR CODED ACCORDING TO LENGTH.

ANY COMBINATION OF INPUTS/OUTPUTS MAY BE CONNECTED BY PATCHING WITHOUT POSSIBLE DAMAGE TO THE ELECTRONICS.

SIGNAL STANDARDS

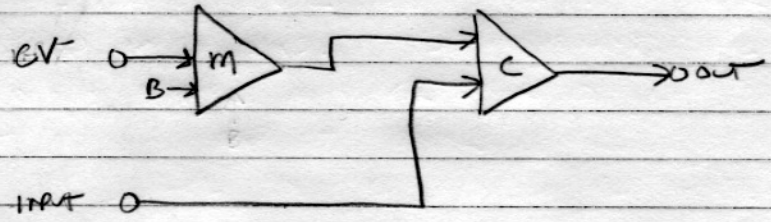
STANDARD AUDIO SIGNAL IS NORMALIZED AT ±5V PEAK TO PEAK.
STANDARD CONTROL SIGNAL IS .. 0 TO +5V
GATE AND TRIGGER INPUTS LOOK FOR A THRESHOLD CROSSING—
NORMALIZED AT ABOUT .5V.
TRIGGER INPUTS ONLY CARE ABOUT A TRANSITION, USUALLY LO TO HI.
GATE INPUTS ALSO ACT AS TO ANY HIGH MAINTAINED ~~SIGNAL~~.
ANY WAVESHAPE MAY BE APPLIED TO THESE TWO INPUTS.
PITCH CONTROL IS 1VOLT PER OCTAVE STANDARD.
INPUT IMPEDENCES ARE 100K NOMINAL
OUPUT .. ARE 1K NOMINAL

BILATERAL SWITCH



AN ELECTRONIC SWITCH, SPDT. THE SWITCH FLIPS TO THE NORMALLY OPEN TERMINAL WHEN THE CONTROL INPUT GATE GROSSES A THRESHOLD OF 2 +1V. THERE IS A SMALL SIGNAL LOSS THROUGH THE SWITCH, AS WELL AS AN INCREASE IN OUPUT Z. THE IMPORTANT LIMITING FACTOR IS THAT THE SWITCH WILL NOT PASS SIGNALS EXCEEDING ± 6V. SIGNALS LARGER THAN THESE LIMITS WILL BE CLIPPED. SIGNALS CAN PASS IN EITHER DIRECTION, WITH THE COMMON TERMINAL BEING USED AS EITHER A SOURCE OR DESTINATION.

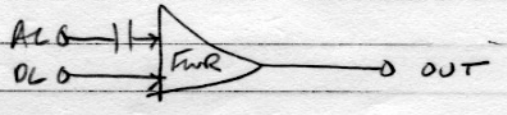
COMPARATOR



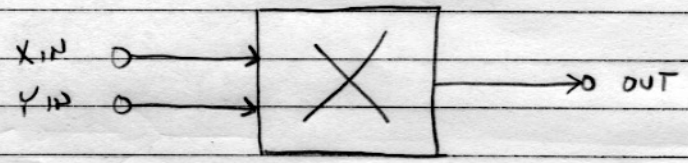
INPUT IS COMPARED WITH A BIAS VOLTAGE AND A CV MIX. IF INPUT IS HIGHER, OUTPUT IS +5V, OTHERWISE ZERO VOLTS. CV IS INVERTED, AND ACTS COUNTER TO KNOB.

FULL WAVE RECTIFIER

ABSOLUTE VALUE CIRCUIT WITH MIXED AC COUPLED + DC COUPLED INPUTS

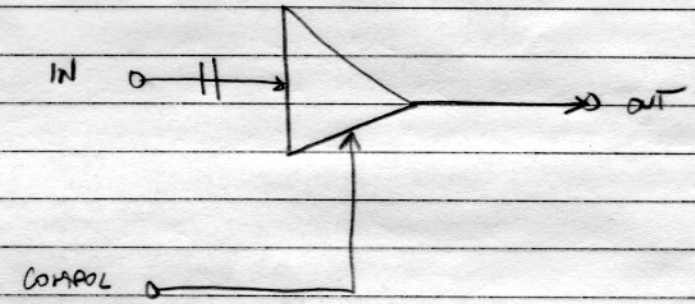


RING MODULATORS



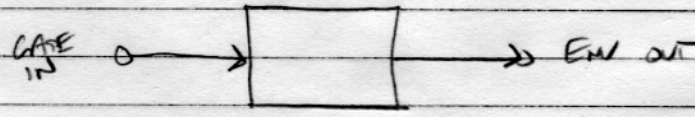
4-QUADRANT VOLTAGE MULTIPLIERS. $V_{out} = \frac{V_x \cdot V_y}{5}$.

VCA



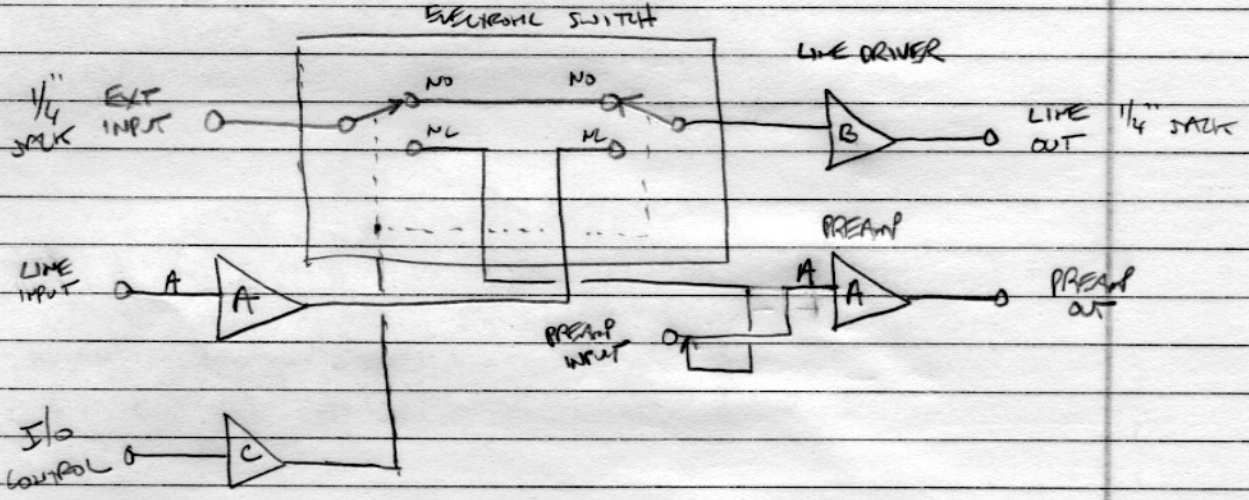
2 QUADRANT MULTIPLIER. THE CONTROL MUST BE POSITIVE. THE INPUT IS AC COUPLED IN THIS VCA; UNITY GAIN IS ACHIEVED WITH THE CV AT +5V. RESPONSE IS LINEARLY PROPORTIONAL TO THE CV.

ENVELOPE GENERATOR



ATTACK AND DECAY TIMES ARE MANUALLY SET AND VARIABLE FROM ___ TO ___. GATE INPUT IS THRESHOLD DETECTED AT ABOUT +1V. MAX ENV IS +5V, MIN IS ØV. ENV SUSTAINS AT +5V WITH CONTINUED HIGH GATE. ACTUAL GATE INPUT LEVEL DOES NOT AFFECT OUTPUT LEVEL.

I/O PROCESSOR



A = ATTENUATED OR VARIABLE GAIN BUFFER
B = FIXED BUFFER
C = COMPARATOR

THIS MODULE PROVIDES INTERFACING FOR HIGH IMPEDANCE MIKES, GUITARS, ETC., PLUS OUTPUT DRIVE FOR HIGH LEVEL MIKE INPUTS ~ <.5V PEAK-PEAK. NORMALLY THE EXT IN IS ROUTED TO THE PREAMP FOR BOOSTING TO SYNTH LEVELS (10V P-P) THE PREAMP HAS A GAIN CONTROL AND A LEVEL LED (GREEN). AT PROPER LEVELS THE LED FLASHES ON INPUT PEAKS. SIMULTANEOUSLY THE LINE DRIVER IS ROUTED TO A LEVEL MATCHER ~~FOR~~ TO SEND THE PROCESSED SIGNAL OUT TO THE AMP AT PROPER LEVELS.

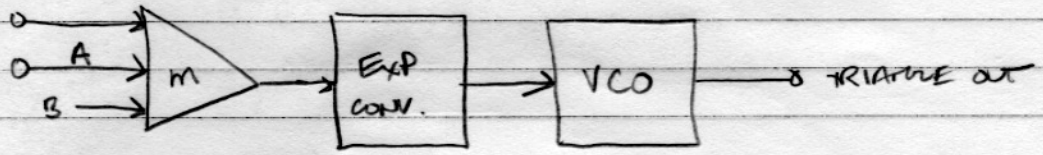
A GATE SIGNAL TO THE I/O CONTROL INPUT WILL FLIP THE SWITCH TO THE "OUT" POSITION, ROUTING THE INPUT SIGNAL STRAIGHT THROUGH TO THE AMP VIA A UNITY GAIN BUFFER. A BOUNCELESS GATE SHOULD BE USED FOR POPLESS SWITCHING.

THE PREAMP INPUT CAN BE ACCESSED FOR BOOSTING SIGNALS WITHIN THE SYNTH. WITH A GAIN OF ~ 6X MAX.

EXT INPUT IMP = 110K
LINE DRIVER OUT Z ~ 680Ω
LINE INPUT Z = ~ 50K
PREAMP INPUT Z ~ 33K
PREAMP OUT Z ~ 1K
CONTROL INPUT Z ~ 100K

} NOT NECESSARY OBTAINABLE FROM SCHEMATICS

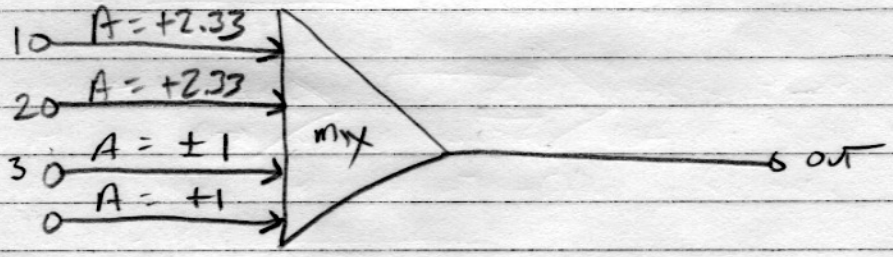
VCO



THIS VCO IS A WIDE RANGE VOLTAGE CONTROLLED TRIANGLE WAVE OSCILLATOR, THE FREQ RANGE BEING FROM .05 HZ TO 20 KHZ. A 1V/OCT INPUT AND AN ATTENUATED CV INPUT ARE PROVIDED.

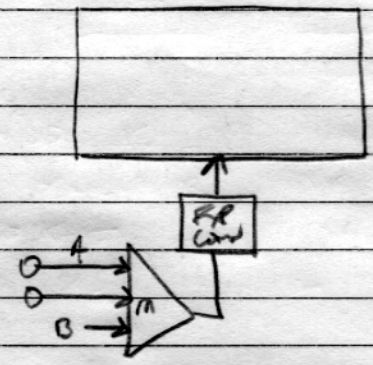
DC MIXER

A 4-IN, 1-OUT DC MIXER. INPUTS 1 + 2 HAVE AUDIO TAPER ATTENUATORS AND CAN PROVIDE A MAXIMUM GAIN OF 2.333. INPUT 3 IS CENTER-OFF, INVERTING TO CCW AND NON-INV TO CLOCKWISE ROTATIONS, MAXIMUM GAIN = ±1. INPUT 4 IS A UNITY GAIN NON INVERTING WILD (NON ATTENUATED) INPUT.



VCF

THIS VCF IS AN EXPERIMENTAL UNCONVENTIONAL 4TH ORDER STATE VARIABLE.



JUST-TUNED SCALE COMPONENT RATIOS

	X Unison	X Octave	Name	Components
1.	1/1	1/2	Unison	U
2.	16/15	8/15	Halftone	HU
3.	10/9	5/9	Minor tone	MU
4.	9/8	9/16	Whole tone	WU
5.	6/5	3/5	Minor third	HWU
6.	5/4	5/8	Major third	MWU
7.	4/3	2/3	Perfect fourth	HMWU
8.	45/32	45/64	Augmented fourth	MW^2U
9.	64/45	32/45	Diminished fifth	H^2MWU
10.	3/2	3/4	Perfect fifth	HMW^2U
11.	8/5	4/5	Minor sixth	H^2MW^2U
12.	5/3	5/6	Major sixth	HM^2W^2U
13.	16/9	8/9	Grave min. 7th	$H^2M^2W^2U$
14.	9/5	9/10	Minor seventh	H^2MW^3U
15.	15/8	15/16	Major seventh	HM^2W^3U
16.	2/1	1/1	Octave	2U

Compiled by Richard Brewster, August 1980

JUST-TUNED SCALE COMPONENT RATIOS

	X Unison	X Octave	Name	Components
1.	1/1	1/2	Unison	U
2.	16/15	8/15	Halftone	HU
3.	10/9	5/9	Minor tone	MU
4.	9/8	9/16	Whole tone	WU
5.	6/5	3/5	Minor third	HWU
6.	5/4	5/8	Major third	MWU
7.	4/3	2/3	Perfect fourth	HMWU
8.	45/32	45/64	Augmented fourth	MW^2U
9.	64/45	32/45	Diminished fifth	H^2MWU
10.	3/2	3/4	Perfect fifth	HMW^2U
11.	8/5	4/5	Minor sixth	H^2MW^2U
12.	5/3	5/6	Major sixth	HM^2W^2U
13.	16/9	8/9	Grave min. 7th	$H^2M^2W^2U$
14.	9/5	9/10	Minor seventh	H^2MW^3U
15.	15/8	15/16	Major seventh	HM^2W^3U
16.	2/1	1/1	Octave	2U

Compiled by Richard Brewster, August 1980

JUST-TUNED SCALE COMPONENT RATIOS

	X Unison	X Octave	Name	Components
1.	1/1	1/2	Unison	U
2.	16/15	8/15	Halftone	HU
3.	10/9	5/9	Minor tone	MU
4.	9/8	9/16	Whole tone	WU
5.	6/5	3/5	Minor third	HWU
6.	5/4	5/8	Major third	MWU
7.	4/3	2/3	Perfect fourth	HMWU
8.	45/32	45/64	Augmented fourth	MW^2U
9.	64/45	32/45	Diminished fifth	H^2MWU
10.	3/2	3/4	Perfect fifth	HMW^2U
11.	8/5	4/5	Minor sixth	H^2MW^2U
12.	5/3	5/6	Major sixth	HM^2W^2U
13.	16/9	8/9	Grave min. 7th	$H^2M^2W^2U$
14.	9/5	9/10	Minor seventh	H^2MW^3U
15.	15/8	15/16	Major seventh	HM^2W^3U
16.	2/1	1/1	Octave	2U

Compiled by Richard Brewster, August 1980

JUST SCALE COMPONENTS

RATIO	DECIMAL	NAME	COMPONENTS
1/1	1.00000	UNISON	
16/15	1.06667	SEMITONE	s
10/9	1.11111	MINOR TONE	m
9/8	1.125000	WHOLE TONE	w
256/225	1.13777		s^2
32/27	1.18519		sm
6/5	1.20000	MINOR THIRD	sw
100/81	1.23457		m^2
5/4	1.25000	MAJOR THIRD	mw
81/64	1.26563		w^2
32/25	1.28000		s^2w
4/3	1.33333	PERFECT FOURTH	swm
27/20	1.35000		sw^2
25/18	1.38888		m^2w
45/32	1.40625	AUGMENTED FOURTH	mw^2
64/45	1.42222	DIMINISHED FIFTH	s^2mw
36/25	1.44000		s^2w^2
40/27	1.48148		sm^2w
3/2	1.50000	PERFECT FIFTH	smw^2
192/125	1.53600		s^3w^2
25/16	1.56250		m^2w^2
128/81	1.58025		s^2m^2w
8/5	1.60000	MINOR SIXTH	s^2mw^2
81/50	1.62000		sw^3
5/3	1.66667	MAJOR SIXTH	sm^2w^2
27/16	1.68750		smw^3
128/75	1.70666		s^3mw^2
125/72	1.73611		m^3w^2
225/128	1.75781	HARMONIC MINOR SEVENTH	m^2w^3
16/9	1.77778	GRAVE MINOR SEVENTH	$s^2m^2w^2$
9/5	1.80000	MINOR SEVENTH	s^2mw^3
50/27	1.85185	GRAVE MAJOR SEVENTH	sm^3w^2
15/8	1.87500	MAJOR SEVENTH	sm^2w^3
250/128	1.95313		m^3w^3
2/1	2.00000	OCTAVE	

1/1	1.00000	UNISON	
16/15	1.06667	SEMITONE	
15/14	1.07143		
14/13	1.07692		
13/12	1.08333		
12/11	1.09091		
11/10	1.10000		
10/9	1.11111	MINOR TONE	
9/8	1.12500	MAJOR TONE	
8/7	1.14286		
15/13	1.15385		
7/6	1.16667		
13/11	1.18182		
6/5	1.20000	MINOR 3RD	
11/9	1.22222		
16/13	1.23077		
5/4	1.25000	MAJOR 3RD	
14/11	1.27273		
9/7	1.28571		
13/10	1.30000		
4/3	1.33333	PERFECT 4TH	
15/11	1.36364		
11/8	1.37500		
7/5	1.40000		
10/7	1.42857		
13/9	1.44444		
16/11	1.45454		
3/2	1.50000	PERFECT 5TH	
14/9	1.55555		
11/7	1.57143		
8/5	1.60000	MINOR 6TH	
13/8	1.62500		
5/3	1.66667	MAJOR 6TH	
12/7	1.71429		
7/4	1.75000	HARMONIC MINOR 7TH (NOT REALLY)	225/128 REALLY
16/9	1.77778	GRAVE MINOR 7TH	
9/5	1.80000	MINOR 7TH	
11/6	1.83333		
13/7	1.85714		
15/8	1.87500	MAJOR 7TH	

	31 TONE SCALE	JUST SCALE TONES		
x 1	1.00000	1.00000	UNISON	1/1
2	1.02261			
x 3	1.04573	1.04167		75/72
x 4	1.06938	1.06667	SEMITONE	16/15
5	1.09356			
x 6	1.11829	1.11111	MINOR TONE	10/9
7	1.14357	1.12500	WHOLE TONE	9/8
8	1.16943			
x 9	1.19587	1.20000	MINOR 3RD	6/5
10	1.22291			
x 11	1.25057	1.25000	MAJOR 3RD	5/4
12	1.27884			
13	1.30776			
x 14	1.33733	1.33333	FOURTH	4/3
15	1.36757			
x 16	1.39849	1.40625	AUG. FOURTH	45/32
x 17	1.43011	1.42222	DIM FIFTH	64/45
18	1.46245			
x 19	1.49552	1.50000	FIFTH	3/2
20	1.52933			
x 21	1.56391	1.56250		25/16
x 22	1.59928	1.60000	MINOR 6TH	8/5
23	1.63544			
x 24	1.67242	1.66667	MAJOR 6TH	5/3
25	1.71023			
26	1.74890			
x 27	1.78845	1.77778	GRAVE MINOR 7TH	16/9
28	1.82889			
x 29	1.87024	1.875	MAJOR 7TH	15/8
30	1.91253			
31	1.95578			

JUST GENERATOR

CAPABLE OF MULTIPLICATION BY

DESIGN CIRCUITS FOR EITHER:

① MULTIPLICATION BY 9/8, 10/9, 16/15

② DIVISION BY SAME

③ MULTIPLICATION BY 8/9, 9/10, 15/16

④ DIVISION BY SAME

1/1	1/1	UNISON
9/16	9/8	SEMITONE WHOLE TONE
3/5	6/5	MINOR THIRD
5/8	5/4	MAJOR THIRD
2/3	4/3	PERFECT FOURTH
3/4	3/2	PERFECT FIFTH
4/5	8/5	MINOR SIXTH
5/6	5/3	MAJOR SIXTH
9/10	9/5	MINOR SEVENTH
15/16	15/8	MAJOR SEVENTH
	2/1	OCTAVE

NEED MULT + DIVIDE BY 9

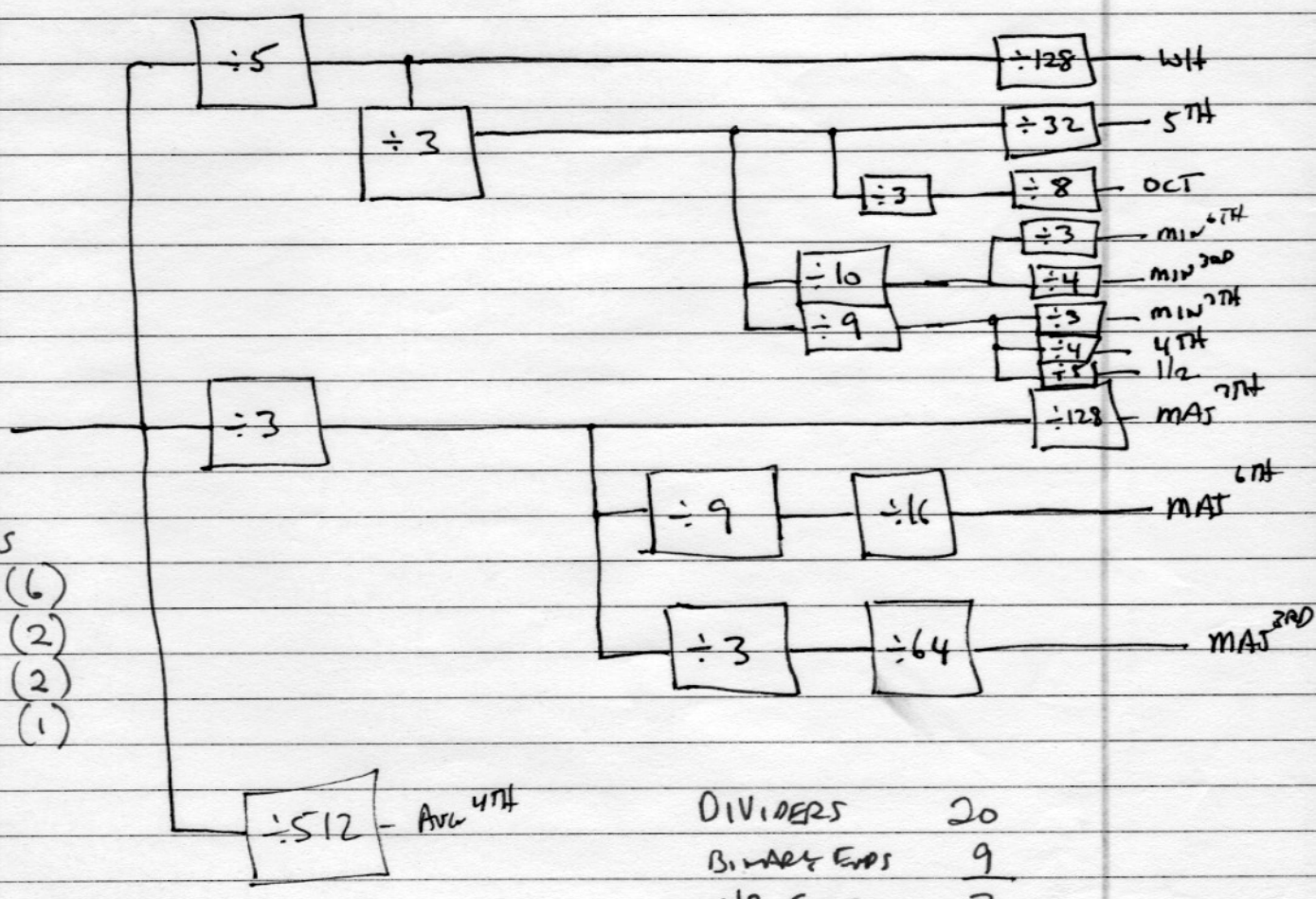
NEED ① MULT BY 10, DIV BY 8, MULT BY 16, DIV BY 15 OR ② DIV BY 10, MULT BY 8, DIV BY 16, MULT BY 15

TONES WANTED:

360/720	1/2	1/1	UNISON	C
360/675	8/15	16/15	HALF TONE	
360/640	9/16	9/8	WHOLE TONE	D
360/600	3/5	6/5	MINOR 3RD	
360/576	5/8	5/4	MAJOR 3RD	E
360/540	2/3	4/3	FOURTH	F
360/480	3/4	3/2	FIFTH	G
360/450	4/5	8/5	MINOR SIXTH	
360/432	5/6	5/3	MAJOR SIXTH	A
360/405	8/9	16/9	GRAVE MINOR SEVENTH	
360/384	15/16	15/8	MAJOR SEVENTH	B
360/360	1/1	2/1	OCTAVE	C
		~~44/45~~	DIMINISHED 5TH	
360/512	45/64	45/32	AUG. 4TH	

✓	1/2	15·9·5	15·15·3
✓	WHOLE	5·128	
✓	MIN 3RD	15·10·4	15·5·8
✓	MAJ 3RD	9·64	
✓	4TH	15·9·4	
✓	AVG 4TH	512	
✓	5TH	15·32	
✓	MIN 6TH	15·6·5	15·15·2
✓	MAJ 6TH	9·6·8	3·9·16
✓	MIN 7TH	15·9·3	
✓	MAJ 7TH	3·128	
✓	OCT	15·3·8	15·6·4

~~15·5·9~~ 15·9·5
15·10·4 ~~15·5·8~~ 15·9·3
15·10·3 ~~15·5·6~~ 15·9·4
~~15·9·3~~
~~15·9·4~~
15·6·4 15·3·8
~~15·12·5~~



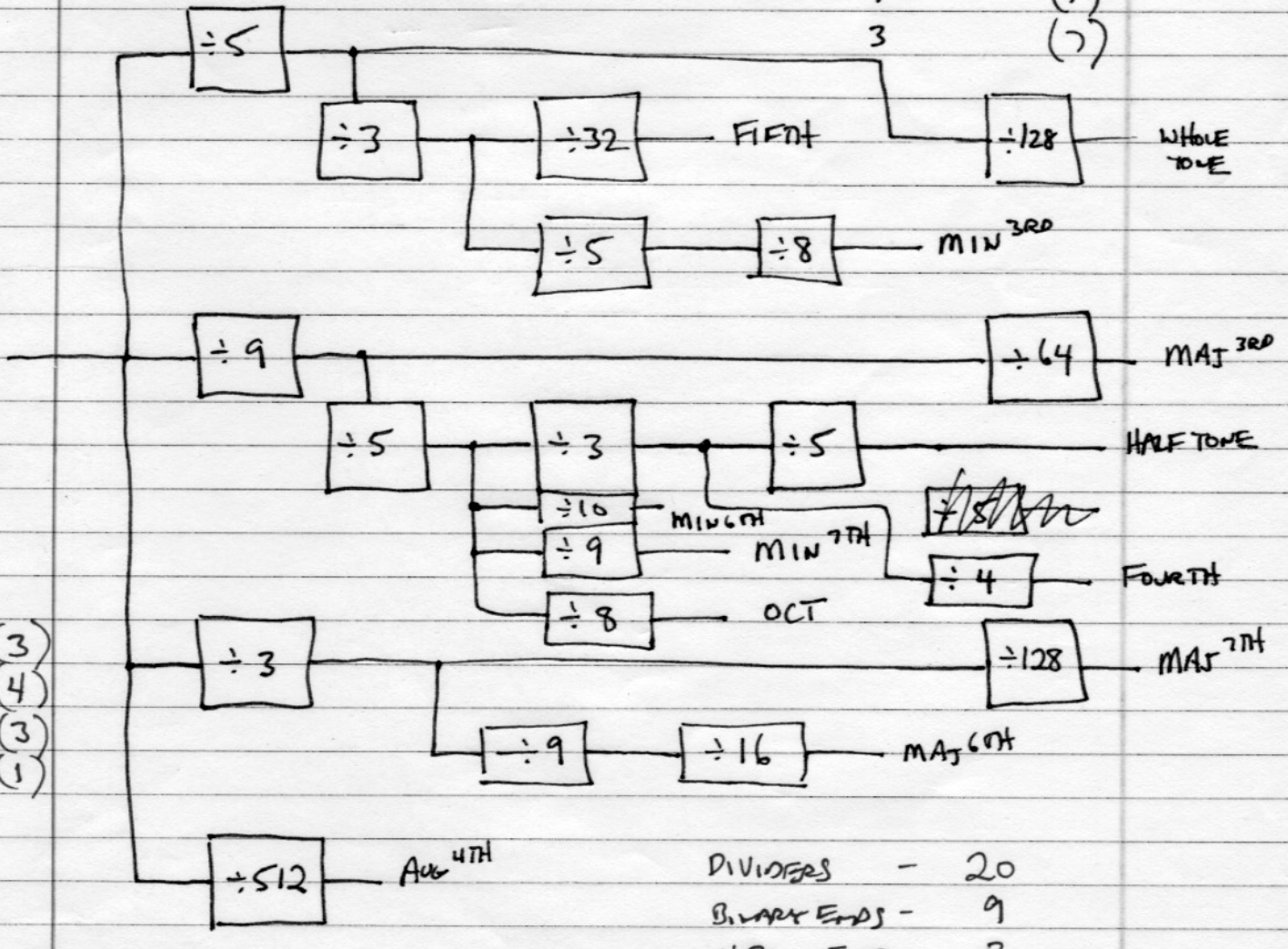
DIVERS
÷3 (6)
÷5 (2)
÷9 (2)
÷10 (1)

DIVIDERS 20
BINARY ENDS 9
NB ENDS 3

DIVISORS

HALF	3 · 9 · 5 · 5
WHOLE	~~10 64~~ ~~5 128~~
MIN 3RD	~~3 5 2 5 4~~ 3 · 5 · 5 · 8
MAJ 3RD	~~9 64~~
FOURTH	~~9 5 2 6~~ 9 · 5 · 3 · 4
AUG 4TH	~~5 8~~
FIFTH	~~5 6 16~~ 5 · 3 · 32
MIN 6TH	9 · 5 · 5 · 2
MAJ 6TH	9 · 3 · 16
MIN 7TH	9 · 5 · ~~3 3~~ 9
MAJ 7TH	~~5 128~~
OCT	9 · 5 · 8

5 · 3	(5)
9 · 5	(5)
~~9 · 3~~	(4)
9 · 5 · 3	(3)
5	(8)
9	(7)
3	(7)



DIVIDERS	
÷3	(3)
÷5	(4)
÷9	(3)
÷10	(1)

DIVISORS	20
BINARY ENDS	9
NB ENDS	3

JUST SCALE INTERVALS

1	UNISON	1.00000	> 1.06667	1	
2	SEMITONE	1.06667	> 1.04167	2	
3	MINOR TONE	1.11111	> 1.01250	5	
4	WHOLETONE	1.12500	> 1.06667	1	
5	MINOR 3RD	1.20000	> 1.04167	2	
6	MAJOR 3RD	1.25000	> 1.06667	1	
7	FOURTH	1.33333	> 1.12500	4	
8	FIFTH	1.50000	> 1.06667	1	
9	MINOR 6TH	1.60000	> 1.04167	2	
10	MAJOR 6TH	1.66667	> 1.06667	1	
11	GRAVE MINOR 7TH	1.77777 / 1.80000	> 1.04167	2	
12	GRAVE MAJOR 7TH	1.85185 / 1.87500			1.80000

INTERVAL #			
1	–	1.06667	SEMITONE
2	–	1.04167	?
3	–	1.01250	?
4	–	1.12500	WHOLE TONE

#2 = $10/9 \cdot 15/16 = \frac{150}{144} = 75/72$

#3 = $9/8 \cdot 80/81 = 81/80$ =

RATIO OF INTERVALS

1.01250 > 1.02881
1.04167 > 1.02400
1.06667 > 1.05469
1.12500

1.05469 > 1.02516
1.02881 > 1.00470 > 1.02036
1.02400

NOTE

1	UNISON	1	> 1.06667	
2	SEMITONE	1.06667	> 1.05469	
3	WHOLETONE	1.12500	> 1.06667	
4	MINOR 3RD	1.20000	> 1.04167	
5	MAJOR 3RD	1.25000	> 1.06667	
6	FOURTH	1.33333	> 1.05469	OR 1.06667
7	AUG 4TH OR DIM 5TH		> 1.06667	OR 1.05469
8	FIFTH	1.50000	> 1.06667	
9	MINOR 6TH	1.6000	> 1.04167	
10	MAJOR 6TH	1.66667	> 1.05469	1.06666
11	HARM OR GRAVE MINOR 7TH		> 1.06666	OR 1.05469
12	MAJOR 7TH	1.87500		

FOURTH TO FIFTH

1.3333 > 1.04167	1.3333 > 1.05469	1.3333 > 1.06666
1.38888 > 1.08000	1.40625 > 1.06666	1.42222 > 1.05469
1.50000	1.50000	1.50000
	AUG 4TH	DIM 5TH

MAJOR 6TH TO MINOR 7TH

1.6667 > 1.04167	1.6667 > 1.05469	1.6667 > 1.06666
1.73611	HARM MINOR 1.75781 > 1.06666	1.7777 > 1.05469
	~~HARM MINOR~~ MAJ 7TH 1.875	1.875

NOTE	NAME	COMPUTATION	RATIO
1	UNISON	1×1	1 : 1
2	SEMITONE	$1 \times 16/15$	16 : 15
3	MINOR TONE	$16/15 \times 15/16 \times 10/9$	10 : 9
4	WHOLE TONE	$10/9 \times 9/10 \times 9/8$	9 : 8
5	MINOR 3RD	$9/8 \times 16/15$	6 : 5
6	MAJOR 3RD	$6/5 \times 15/16 \times 10/9$	5 : 4
7	FOURTH	$5/4 \times 16/15$	4 : 3
8	FIFTH	$4/3 \times 9/8$	3 : 2
9	MINOR 6TH	$3/2 \times 16/15$	8 : 5
10	MAJOR 6TH	$8/5 \times 10/9 \times 15/16$	5 : 3
11	GRAVE MINOR 7TH	$5/3 \times 16/15$	16 : 9
12	GRAVE MAJOR 7TH	$16/9 \times 10/9 \times 15/16$	50 : 27

THIS 12 TONE SCALE IS BASED ON THE RATIOS :

16 : 15

10 : 9

9 : 8

12 NOTE JUST SCALE

		INTERVAL	
1	1/1	1/1	UNISON
2	(1/1)(16/15)	16/15	SEMITONE
3	(1/1)(9/8)	9/8	MAJOR TONE
4	(9/8)(16/15)	6/5	MINOR 3RD
5	(9/8)(10/9)	5/4	MAJOR 3RD
6	(5/4)(16/15)	4/3	FOURTH
7	(5/4)(9/8) (4/3)(16/15)	45/32 64/45	AUGMENTED FOURTH DIMINISHED FIFTH
8	(4/3)(9/8)	3/2	FIFTH
9	(3/2)(16/15)	8/5	MINOR 6TH
10	(3/2)(10/9)	5/3	SIXTH
11	(5/3)(16/15)	16/9	GRAVE MINOR SEVENTH
12	(5/3)(9/8)	15/8	MAJOR 7TH

JUST TUNING COMPONENTS

1	1/1	1/2	UNISON	1	>
2	16/15	8/15	HALF TONE	H	>
3	10/9	5/9	MINOR TONE	m	>
4	9/8	9/16	WHOLE TONE	W	>
5	6/5	3/5	MIN 3RD	HW	>
6	5/4	5/8	MAJ 3RD	mW	>
7	4/3	2/3	4TH	HmW	>
8	45/32	45/64	AUG 4TH	mWW	>
9	64/45	32/45	DIM 5TH	HHmW	>
10	3/2	3/4	FIFTH	HmWW	>
11	8/5	4/5	MIN 6TH	HHmWW	>
12	16/9 5/3	5/6	MAJ 6TH	HmmWW	>
13	9/5 16/9	8/9	GRAVE MIN 7TH	HHmmWW	>
14	15/8 9/5	9/10	MINOR 7TH	HHmWWW	>
15	2/1 15/8	15/16	MAJ 7TH	HmmWWW	>
16	2/1	1/1	OCTAVE	2	

SCALE GENERATION FOR

S = 16/15 HALFTONE

m = 10/9 MINOR TONE

W = 9/8 WHOLE TONE

~~REDUCT~~ COMBINATIONS TO 3RD POWER (NO DUPLICATES)

	TERMS 1	2	3	4	5	6
S	S	Sm	SmW	S^2mW	S^2m^2W	$S^2m^2W^2$
m	m	SW	S^2m	Sm^2W	S^2mW^2	Sm^3W^2
W	W	mW	S^2W	SmW^2	Sm^2W^2	Sm^2W^3
Sm		S^2	Sm^2	S^2m^2	S^3mW	S^2mW^3
SW		m^2	SW^2	S^2W^2	Sm^3W	S^3mW^2
mW		W^2	mW^2	m^2W^2	SmW^3	S^2m^3W
SmW			m^2W	S^3m	S^3m^2	S^3m^2W
S^2			S^3	S^3W	S^3W^2	S^3m^3
S^2m			m^3	m^3W	m^3W^2	S^3W^3
S^2W			W^3	Sm^3	S^2m^3	m^3W^3
m^2				mW^3	m^2W^3	
Sm^2				SW^3	S^2W^3	
m^2W						
W^2						
SW^2						
mW^2						
S^2mW						
Sm^2W						
SmW^2						
S^2m^2W						
S^2mW^2						
Sm^2W^2						
$S^2m^2W^2$						
1.21363 S^3						
1.37174 m^3						
1.42383 W^3						

$\frac{1024}{729}$ 243

$\frac{25}{16}$

$\frac{10}{9} \cdot \frac{81}{64}$

$\frac{320}{243}$

$\frac{16}{25}$

$\frac{512}{405}$

A = 4
B = 5

$(AB)^2$ 400

A^2B^2

1/1 1.00000

$\frac{2}{1}\cdot\frac{10^2}{9_3}\quad\frac{4}{3}$

LET $^{16}/_{15}$ = S SEMITONE
LET $^{10}/_{9}$ = M MINOR TONE
LET $^{9}/_{8}$ = W WHOLE TONE

1	1·S	=	S		
2	1·M	=	M		
3	1·W	=	W		
4	SW	=	MINOR 3RD	$^{6}/_{5}$	
5	MW	=	MAJOR 3RD	$^{5}/_{4}$	
	SM	=	$^{2}\frac{16}{15}$	$=\frac{32}{27}$	= 1.18519
S^2W	$^{6}/_{5}\cdot{}^{16}/_{15}$	=	$^{96}/_{75}$	$=\frac{32}{25}$	= 1.28000
SWM	$^{2}6/_{5}\cdot{}^{10}/_{9_3}$	=	$^{4}/_{3}$	= FOURTH	1.33333
SW^2	$^{3}6/_{5}\cdot{}^{9}/_{8_4}$	=	$\frac{27}{20}$		= 1.35000

$4/3$ $6/5$ $4/3$ $4/3$ $4/3$ $4/3$

$S^2 = \frac{256}{225}$ $m^2 = \frac{100}{81}$ $W^2 = \frac{81}{64}$

	SMW	$^{9}/_{4}\cdot\frac{16}{15}$	=	$^{4}/_{3}$	FOURTH
m^2W	~~MMW~~	$^{5}/_{4}\cdot{}^{10}/_{9}$	=	$^{50}/_{36}=\frac{25}{18}$	= 1.38888
W^2m	~~WWM~~	$^{5}/_{4}\cdot{}^{9}/_{8}$	=	$\frac{45}{32}$ AUG 4TH	= 1.40625
S^2Wm	SSWM	$^{4}/_{3}\cdot{}^{16}/_{15}$	=	$\frac{64}{45}$ DIM 5TH	= 1.42222
m^2WS	MSWM	$^{4}/_{3}\cdot{}^{10}/_{9}$		$\frac{40}{27}$	= 1.48148
W^2MS	WSWM	$^{4}/_{3}\cdot{}^{9}/_{8}$		$^{36}/_{24}=^{3}/_{2}$ FIFTH	= 1.50000

S^2W^2m $^{3}/_{2}\cdot{}^{16}/_{15}=\frac{48}{30}=\frac{8}{5}$ MIN 6TH = 1.6000
SW^2m^2 $^{3}/_{2}\cdot{}^{10}/_{9}=\frac{30}{18}=\frac{5}{3}$ MAJ 6TH = 1.66667
~~3/2~~
$S^2W^2m^2$ $^{5}/_{3}\cdot{}^{16}/_{15_3}=\frac{16}{9}$ = GRAVE MIN 7TH = 1.77778

$SW^3m^2=\frac{5}{1}\cdot\frac{27}{8}=\frac{15}{8}$ MAJOR 7TH = 1.875

1

$s = 16/15$ ✓ SEMI

$m = 10/9$ ✓ MINOR TONE

$w = 9/8$ ✓ MAJOR TONE

2

$sm = 32/27$ +.18519

$sw = 6/5$ ✓ +.20000

$mw = 5/4$ ✓ +.25000

$s^2 = 256/225$ +.13777 SHARP MAJOR TONE

$m^2 = 100/81$ +.23457 FLAT MAJOR 3RD

$w^2 = 81/64$ +.26563 SHARP MAJOR 3RD

3

$s^3 = 4096/3375$

$m^3 = 1000/729$

$w^3 = 729/512$

$swm = 4/3$ ✓ +.33333

$s^2m = 2560/2025 = 512/405$

$s^2w = 32/25$ +.28000

$sm^2 = 320/243$

$sw^2 = 27/20$ +.35000

$mw^2 = 45/32$ +.40625

$m^2w = 25/18$ +.38888

4

$smw(w) = 3/2$ ✓ +.50000

$smw(m) = 40/27$ +.48148

$smw(s) = 64/45$ +.42222

$(sm)^2 = 1024/729$

$(sw)^2 = 36/25$ +.44000

$(mw)^2 = 25/16$ +.56250

$sm \cdot s^2 = 32/27 \cdot 256/225 = \frac{8192}{6075}$

$sw \cdot s^2 = 6/5 \cdot 256/225 = \frac{1536}{1125}$

$mw \cdot m^2 = 5/4 \cdot 100/81 = \frac{500}{324} = \frac{250}{162}$

$sm \cdot m^2 = 32/27 \cdot 100/81 = \frac{3200}{2187}$

$mw \cdot w^2 = 5/4 \cdot 729/512 = \frac{3645}{2048}$

$sw \cdot w^2 = 6/5 \cdot 81/64 = \frac{486}{320} = \frac{243}{160}$

(smw)(sm)	$4/3 \cdot 32/27$	$= 128/81$	~~1.58025~~
(smw)(sw)	$4/3 \cdot 6/5$	$= 24/15 = \times 8/5$ ✓	~~1.60000~~
(smw)(mw)	$4/3 \cdot 5/4$	$= \times 5/3$ ✓	~~1.6667~~
$(smw)\ s^2$	$4/3 \cdot 256/225$	$= 1024/675$	
$(smw)\ m^2$	$4/3 \cdot 100/81$	$= 400/243$	
$(smw)\ w^2$	$4/3 \cdot 81/64$	$= 324/192 = 162/96 = 81/48 = 27/16$	~~1.68750~~
$(sm)^2 \cdot s$	$1024/729 \cdot 16/15$	$= 16384/10935$	
$(sw)^2 \cdot s$	$36/25 \cdot 16/45$	$= 192/125$	~~1.53600~~
$(mw)^2 \cdot m$	$25/16 \cdot 25/9$	$= 125/72$	~~1.73611~~
$(sm)^2 \cdot m$	$1024/729 \cdot 10/9$	$= 10240/6561$	
$(mw)^2 \cdot w$	$25/16 \cdot 9/8$	$= 225/128$ $7/4$	~~1.75781~~
$(sw)^2 \cdot w$	$36/25 \cdot 9/8$	$= 81/50$	~~1.62000~~
$(sm)^2 \cdot w^2$	$1024/729 \cdot 81/64$	$= \times 16/9$ ✓	~~1.77778~~
$smw \cdot m^2w$	$4/3 \cdot 25/18$	$= 100/54 = 50/27$	~~1.85185~~
$smw \cdot mw^2$	$4/3 \cdot 15/32$	$= \times 60/32 = 15/8$	~~1.87500~~
$smw \cdot sw^2$	$4/3 \cdot 27/20$	$= \times 36/20 = 9/5$ ✓	~~1.80000~~
$smw \cdot s^2w$	$4/3 \cdot 32/25$	$= 128/75$	~~1.706666~~
$smw \cdot sm^2$	$4/3 \cdot 320/243$	$= 1280/729$	
$smw \cdot s^2m$	$4/3 \cdot 512/405$	$= 2048/1215$	
s^3m^3	$4096/3375 \cdot 1000/729$		
s^3w^3	$4096/3375 \cdot 729/512$		
m^3w^3	$1000/729 \cdot 729/512$	$= 250/128$	1.95313

MAJOR JUST SCALE

UNISON	1/1	→ 9/8
WHOLE TONE	9/8	→ 10/9
MAJOR 3RD	5/4	→ 16/15
FOURTH	4/3	→ 9/8
FIFTH	3/2	→ 10/9
MAJOR 6TH	5/3	→ 9/8
MAJOR 7TH	15/8	→ 16/15
OCTAVE	2/1	

$\frac{5}{4} \cdot \frac{8}{9}^2$ 10/9

$4/3 \cdot \frac{4}{5}$ 16/15

$3/2 \cdot 3/4$ 9/8

$5/3 \cdot 2/3$ 10/9

$15/8 \cdot \frac{3}{5}$

$\frac{2}{1} \cdot \frac{8}{15}$

$2x = \frac{15}{8}$ $\frac{15}{16}$

$\frac{2}{1} \cdot \frac{5}{9}$ 10/9

$2 \cdot \frac{15}{16} = \frac{30}{16} = \frac{15}{8}$

$\frac{10}{9} x = \frac{3}{5} \cdot \frac{9}{10_5}$ $\frac{27}{25}$

$3\frac{6}{5} \cdot \frac{9}{10_5}$ $\frac{27}{25}$

$\frac{5}{4} \cdot \frac{9}{10_2}$ 9/8

MINOR JUST SCALE

UNISON	1/1	→ 9/8
WHOLETONE	9/8	→ 16/15
MINOR 3RD	6/5	→ 10/9
FOURTH	4/3	→ 9/8
FIFTH	3/2	→ 16/15
MINOR 6TH	8/5	→ 9/8
MINOR 7TH	9/5	→ 10/9
OCTAVE	2/1	

$6/5 \cdot 8/9$ $48/45$ $16/15$

$4/3 \cdot 5/6_3 =$ 10/9

$3/2 \cdot 3/4$ 9/8

$8/5 \cdot 2/3$ 16/15

$\frac{8}{5} \cdot \frac{16}{15} = \frac{128}{75}$

$\frac{8}{5} \cdot \frac{10^2}{9} =$ 16/9 GRAVE MINOR 7TH

$\frac{8}{5} \cdot \frac{9}{8} =$ 9/5 MINOR 7TH

$\frac{2}{1} \cdot \frac{9}{16}$ 18/16 9/8

$\frac{9}{9}$ $16/9 \cdot \frac{18}{16} =$

$15/8 \cdot \frac{8}{9}$ 5/3

$3\frac{27}{25_5} \cdot \frac{10^2}{4}$ 6/5

$\frac{16}{9} \cdot \frac{3}{5}$ $\frac{16}{15}$

$2 \cdot \frac{9}{16} = \frac{18}{16}$ 9/8